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The ability of analytical thinking and chemistry literacy in high school students learning

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Abstract. The objective in this study was to determine the analytical thinking and chemical literacy skill of senior high school students. This study was quantitative descriptive method describing the integrated skill of analytical thinking and student’s chemistry literacy. There were 185 students of 12th grade science in Kulon Progo in academic year 2017/2018 used as a sample. In this study, the data were obtained from interviewing, delivering questionnaire, and delivering test of integrated multiple choice with the number of 30 question about hydrolysis concept. The reliability of test was found to be 0.94. The integrated instrument aspects consisting of 4 indicators: explaining the phenomena by distinguishing chemistry concept, organizing chemistry problems by using chemistry understanding, analyzing the strategies and the benefits of chemistry applications, and explaining the relationship among phenomena by using chemistry concept. The result showed that the integrated ability between analytical thinking and chemical literacy ability of the hydrolysis concept of the students is 56.76%. Thus, it can be concluded that the integrated ability between analytical thinking ability and chemical literacy of the students is fair.

1. Introduction
Assessment is one of the most important parts of the learning process [1]. Assessment is used to determine students’ the ability in achieving learning objectives. Therefore, assessment is a very important aspect to be conducted in a learning.

Assessment is expected to reflect the students' overall ability in terms of knowledge, attitude, and skills [2]. Assessments are designed and implemented by the teacher that correspond to the planning and implementation of the lesson. One of the ways used in the assessment is by using the technique of collecting data of the test, through which we can know the ability of students to receive the learning that has been given.

Assessment activities conducted by teachers are generally only for measuring cognitive aspects. Assessment of cognitive aspects performed in daily evaluation activities often measures the low cognitive levels only. This causes students to have little chance of being able to think analytically optimally. Teacher’s assessment has a great opportunity to stimulate students' analytical thinking skill.
In addition to analytical thinking, teacher can also stimulate students' chemistry literacy skill.
In the process of learning chemistry, the questions given to students only aim to identify understanding and only focus on the material presented in learning process and in textbooks. It is intended to analyze what students have learned. Some problems are rarely emphasized in high-level thinking skills, such as critical thinking, analytical thinking, and problem solving. Only some types of questions can
challenge students to think deeper and more critical. Therefore, chemistry teacher need to support students in working on tasks and problems which involve high order thinking skill [3].

Analytical thinking skill is needed by students in chemistry learning because almost in every standard of competence in chemistry subject consists of basic competence requiring C4 cognitive domain proposed by Bloom's taxonomy. If the student has good analytical thinking skill, he / she will be better prepared to face the challenges in daily life in the future. Ramirez & Ganaden (2008) explain that the indicators of analytical thinking skill are [4] as those shown in Table 1.

<table>
<thead>
<tr>
<th>Cognitive Process</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyzing</td>
<td>Splitting the material into parts, and determine how the parts are related to each other and the overall structure.</td>
</tr>
<tr>
<td>Distinguishing</td>
<td>Distinguishing relevant or important sections with irrelevant or unimportant sections.</td>
</tr>
<tr>
<td>Organizing</td>
<td>Determining how an element fits its structure.</td>
</tr>
<tr>
<td>Relating</td>
<td>Determining the existence of an element that based on point of view, value or purpose.</td>
</tr>
</tbody>
</table>

According to James Rutherford [5] scientific literacy refers to all forms of literacy related to science, whereas scientific literacy is a form of literacy that refers to all subjects of the disciplines, such as language, social sciences, and science.

According to Shwartz, Ben-Zvi & Hofstein (2006) students' literacy skills should be conducted in an effective manner that enhances students' abilities [6] as those shown in Table 2.

<table>
<thead>
<tr>
<th>No</th>
<th>Aspect</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explaining the phenomena using chemistry concept</td>
<td>Recognizing the importance of chemical knowledge in explaining everyday phenomena. Understanding the theory, models and concepts of chemistry. Subject theory covers a wide and deep application.</td>
</tr>
<tr>
<td>2.</td>
<td>Using a chemical understanding of problem solving</td>
<td>Using an understanding of chemistry in everyday life, as a consumer of new products and new technologies, in making decisions, and participating in social debates on chemical issues. Understanding how chemistry and chemical-based technologies relate to one another. Chemistry produces an explanation of nature. The models and concepts produced by both have a strong connection, so that one with the other will affect each other.</td>
</tr>
<tr>
<td>3.</td>
<td>Analyzing the strategies and benefits of chemical applications</td>
<td>Understanding the relationship between innovation in chemical and sociological and cultural processes (the importance of applications such as drugs, fertilizers, and polymers). Appreciating the impact of chemistry and chemical technology related to society. Understanding the nature of the prevailing chemical phenomena. Producing a change or variation on a better phenomenon by changing the world we see or see from different angles.</td>
</tr>
</tbody>
</table>

The integrated assessment presents an opportunity to synthesize diverse knowledge, data, methods, and perspectives to address complex issues [7]. Integrated assessment is one of the innovations in the
assessment that can make it easier for teachers to evaluate student learning outcomes. Using an integrated assessment teachers can simultaneously measure two aspects at a time. The integrated assessment referred in this thesis is to assess the analytical thinking ability and chemistry literacy in one instrument simultaneously.

The aspect of integrated assessment in this research are as the following.
1. Explaining the phenomena by distinguishing chemistry concept
2. Organzing chemistry problems by using chemistry understanding
3. Analyzing the strategies and the benefits of chemistry applications
4. Explaining the relationship among phenomena by using chemistry concept.

Hydrolysis is the material contained in the chemistry subjects in curriculum 2013. In hydrolysis material the ability of analytical thinking and literacy ability of science students can be explored simultaneously because the material is a complex material connected with other chemical concepts of acid-base and the concept of pH. Based on the nature of the hydrolysis properties, the proper assessment includes analytical thinking skill and literacy of chemistry.

2. Method
2.1. Research Design. The research design used was quantitative research using descriptive method (descriptive-quantitative) that is research picturing size, amount, or frequency. The collection and processing data was done by presenting the data obtained.

2.2. Time and Place of Study. This research was conducted in January 2018 at two of senior high schools in Kulon Progo by taking 6 classes as samples.

2.3. Research Subject. Population in this research were all XII grade students at two of senior high schools in Kulon Progo in the second semester of the academic year 2017/2018. The sample in this study were 185 students.

2.4. Procedure. Descriptive research is a study intended to investigate the conditions that the results were presented in the form of research reports [8]. This study describes the integrated capability of analytical thinking skill and student's chemistry literacy.
In this study the data were obtained from the test result of integrated multiple choice test consisting of 30 questions about the concept of salt hydrolysis. The obtained data is the value of the integrated multiple choice test which then analyzed quantitatively using descriptive statistics with the average calculation of research results in percentage (%) form that presented in the form of tables and graphs to draw conclusion.

2.5. Data Collection Techniques. Data collection techniques in this research were interviews, questionnaires, and test. Interviews are used to find the problems in this research, and to know the detailed information about the respondents [9]. Interviews were conducted to 4 chemistry teachers related to the analytical thinking skill and chemistry literacy of the students. The questionnaire is a statement used to obtain information from the students of a report about the things that they know [10]. The questionnaire was distributed to 185 students who had undertaken the hydrolysis material. The test consisted of a set of questions that must be finished by students. Students were given a set of test consisting of 30 multiple choice questions. Reliability coefficient was found 0.94. The time allocation used in the study was 90 minutes. The achievement test was distributed to students to determine the mastery level of analytical thinking skill and chemistry literacy on the hydrolysis.

The instruments used are interview guides, questionnaires, and a set of questions that contains hydrolysis matter. The interview guide contains questions asked to chemistry teachers related to the analytical thinking skill and chemistry literacy of the students, while the questionnaire for the students contains how the students understand about analytical thinking skill and chemistry literacy.
The questionnaire measures four aspects of the analytical thinking skill and chemistry literacy. The questionnaire used Likert scale with four alternative answers. This scale was arranged in a form of statements and followed by response options that indicates the level. The test contains the problems that must be done by students. Question contains the hydrolysis material which amounted to 30 questions. Students completed the task in 90 minutes. Student answers should be accompanied by reasons that support the answer. The chemistry literacy of the students can be analyzed through the questionnaire result.

2.6. Data Analysis Technique

Data analysis techniques used to determine the analytical thinking skill and chemistry literacy of the students based on the result of the questionnaire and supported by the result of interview with the teachers.

Stages of data analysis conducted in this study were as the followings:

a. calculating the score of test calculation
b. cetermining the average score of learners
c. determining the percentage of integrated aspect, and
d. analyzing the results of the integrated aspect

The percentage of achievement of analytical thinking ability and chemical literacy of students was interpreted descriptively based on student learning outcomes proposed by Arikunto (2006) as shown in the Table 3 [11].

Table 3. Criteria of Student Learning Outcomes

<table>
<thead>
<tr>
<th>Value</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 – 100</td>
<td>Very Good</td>
</tr>
<tr>
<td>66 – 79</td>
<td>Good</td>
</tr>
<tr>
<td>56 – 65</td>
<td>Fair</td>
</tr>
<tr>
<td>40 – 55</td>
<td>Low</td>
</tr>
<tr>
<td>30 – 39</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

The results of the research in the form of integrated multiple choice test on hydrolysis concept was interpreted based on study result criteria for both the overall integrated capability and the value of integrated capability for each indicator.

3. Results and Discussion

3.1. Results

Achievement of integrated ability between analytical thinking ability and overall student chemistry literacy was obtained by calculating the average of students’ score who answer the problem correctly on each item. The result of the percentage of students’ score who answered the question correctly on each item was presented in Table 4.

Table 4. Percentage of number of correct Students’ Score in each item.

<table>
<thead>
<tr>
<th>No.</th>
<th>N a</th>
<th>Percentage (%) b</th>
<th>No.</th>
<th>N a</th>
<th>Percentage (%) b</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>154</td>
<td>83.24</td>
<td>16.</td>
<td>86</td>
<td>46.49</td>
</tr>
<tr>
<td>2.</td>
<td>135</td>
<td>72.97</td>
<td>17.</td>
<td>78</td>
<td>42.16</td>
</tr>
<tr>
<td>3.</td>
<td>137</td>
<td>74.05</td>
<td>18.</td>
<td>137</td>
<td>74.05</td>
</tr>
<tr>
<td>4.</td>
<td>125</td>
<td>67.57</td>
<td>19.</td>
<td>118</td>
<td>63.78</td>
</tr>
<tr>
<td>5.</td>
<td>155</td>
<td>83.78</td>
<td>20.</td>
<td>95</td>
<td>51.35</td>
</tr>
<tr>
<td>6.</td>
<td>98</td>
<td>52.97</td>
<td>21.</td>
<td>149</td>
<td>80.54</td>
</tr>
<tr>
<td>7.</td>
<td>106</td>
<td>57.30</td>
<td>22.</td>
<td>96</td>
<td>51.89</td>
</tr>
<tr>
<td>8.</td>
<td>98</td>
<td>52.97</td>
<td>23.</td>
<td>69</td>
<td>37.30</td>
</tr>
</tbody>
</table>
According to Table 3 the average result of integrated ability of analytical thinking skill and chemistry literacy of students in hydrolysis was 56.76%. This result indicate that student’s analytical thinking skill and chemistry literacy on hydrolysis were still in the fair category.

3.2. Discussion
In this study, each student’s answers were analyzed according to the rubric scores. The students’ answers was analyze by using descriptive approach, i.e by giving a score of each stage for the correct answers. The results were collected and then analyzed descriptively to determine the level of students’ achievement on integrated ability of analytical thinking skill and chemistry literacy.

Based on Table 4, it was found that the average achievement of integrated ability between analytical thinking skill and student literacy on hydrolysis concept was 56.76% with fair achievement category. In addition, Table 2 also shows that there were 3 questions answered in very good category achievement, 5 questions were included in good category, 6 questions were answered in fair category, 10 questions were included in low category, and the other 6 questions were in very low category. In general, the comparison of the amount of questions for each categories was presented in Figure 1.

![Figure 1. The amount of question for each categories.](image)

The result related to the integrated ability between analytical thinking skill and students’ chemistry literacy on the concept of hydrolysis was obtained by calculating the percentage of achievement of test for each indicator on the integrated aspect. This percentage was obtained by comparing the total score of each indicator with the total score for all indicators in integrated ability achievement. Percentage of integrated ability achievement for each indicator on integrated aspect was shown in Table 5.
Table 5. Integrated Capability Test Result for Each Indicator on Integrated Aspect

<table>
<thead>
<tr>
<th>No.</th>
<th>Integrated Aspect</th>
<th>Percentage (%)</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explaining the phenomena by distinguishing chemistry concept</td>
<td>66.11</td>
<td>Good</td>
</tr>
<tr>
<td>2.</td>
<td>Organizing chemistry problems by using chemistry understanding</td>
<td>52.73</td>
<td>Low</td>
</tr>
<tr>
<td>3.</td>
<td>Analyzing the strategies and the benefits of chemistry applications</td>
<td>52.77</td>
<td>Low</td>
</tr>
<tr>
<td>4.</td>
<td>Explaining the relationship among phenomena by using the chemistry concept</td>
<td>49.46</td>
<td>Low</td>
</tr>
</tbody>
</table>

Based in Table 5, it could be obtained information that the achievement of integrated ability in the first aspect was 66.11%, the second aspect was 52.73%, the third aspect was 52.77%, and the fourth aspect was 49.46%. All of those belonging to low categories. This percentage of the integrated aspects was presented in Figure 1.

![Figure 2. Percentage of Integrated Aspect](image)

When the data was observed as a whole, the percentage of integrated ability between analytical thinking skill and student's chemical literacy on hydrolysis material was 56.76%. The results of this study indicate that students' integrated ability was in fair category. This indicated that students were not yet quite familiar with the learning activities according to scientific steps, and have not been able to understand the whole content of hydrolysis. This mean the learning activities of students were still required by student master that to connect the whole content chemistry materials, connected and applied to the phenomenon in their environment in daily life.

The low ability of analytical thinking and chemical literacy in students using integrated assessment instruments is due to differences in learning targets applied in schools with the goal of chemical literacy. Chemistry learning in schools, including its assessment, is more limited to chemical material, while the target in PISA is the application of scientific thinking in daily life [12]. In addition, students are not accustomed to working on questions that have readings and graphics that require precision in work. This is consistent with the opinion of Rustaman that in working on literacy questions requires careful reading and the ability to understand the contents of the reading [13].

The results of interviews to teachers was obtained at the low ability of analytical thinking and chemical literacy of students, as indicated by the lack of important factors, particularly the evaluation activities at the end of the material. Teachers tend to simplyfied the material in preparing lesson.
planning. Problems that were made do not contain the chemistry literacy aspect because it was considered still difficult in preparing lesson plan. That was only a few learning topics which developed into questions that were considered to unable of measuring the chemistry literacy. In addition, teachers tend to make more calculations and more often. This caused students could only develop mathematical skills only rather than chemical skill.

Therefore, in order to gain the achievement of integrated capability between analytical thinking and chemistry literacy, it is necessary that learning activities are begun by using observing activities and linking learning materials to phenomenon that happened in daily life. Through these students’ activities should stimulate to be able to build their knowledge and can find the fact that there is a relationship between the phenomenon occurred by using the lesson subjects in school. The lessons should train the science skills so that students are accustomed to do things related to activities which provide scientific explanations of phenomena, problem solving, and which analyze the benefits of chemical applications [14]. While on the evaluation activities at the end of the delivery of learning materials, students need to introduce with an oriented problem on improving the ability of analytical thinking and chemistry literacy.

In hydrolysis, many chemical aspect can be linked and applied to daily life and can be considered to arise the problems that should result in students' analytical thinking and chemistry literacy skills. It should be noted that the development of questions that can be used for the measurement of science literacy needs to take into account the criteria of science literacy program for International Student Assessment (PISA) in order that students' science literacy skills in Indonesia become better and can contribute in world industries.

4. Conclusion
The percentage of integrated ability of analytical thinking skill and chemistry literacy in senior high school students of hydrolysis concept was found to be 56.76%, so it can be concluded that the integrated ability of analytical thinking skill and chemistry literacy in senior high school in hydrolysis was fair. This showed that students' analytical and literacy skills through classroom learning activities have not been fully develop. Therefore, teachers need to improve students' cognitive and psycho-motor areas effectively in the learning process.

References
[6] Y Shwartz, R Ben-Zvi, A Hofstein 2006 The Use of Scientific Literacy Taxonomy for Assessing The Development of Chemical Literacy Among High-School Students *Chemistry Education Research and Practice* 7 4
[12] H Fives, W Huebner, A S Birnbaum, M Nicolich 2014 Developing A Measure of Scientific Literacy For Middle School Students *Science Education* 98 4

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